Holographic Pomeron

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What about the initial scattering state in AdS/CFT (holographic QCD)

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Overview

scattering in QCD:

- initial scattering state (Glauber, lightcone wave functions, color glass condensate (CGC), ...)
  Q: *'Partonic' initial state picture in holographic QCD?*
- entropy production (CGC, shockwave collision in AdS/CFT, ...)
  Q: *How to produce entropy from scattering amplitude in holographic QCD?*
- hydrodynamic stage
- hadronization into colorless objects

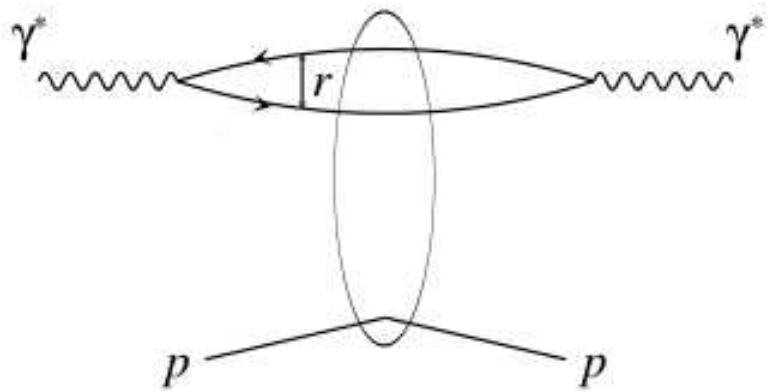
High energy hadron-hadron scattering

Experiment: pp **cross section rises with energy**: $\sigma_{tot}(s) \sim s^{\#}$

Theory: **NON-PERTURBATIVE!**

Introduce the pomeron - object with vacuum quantum no.

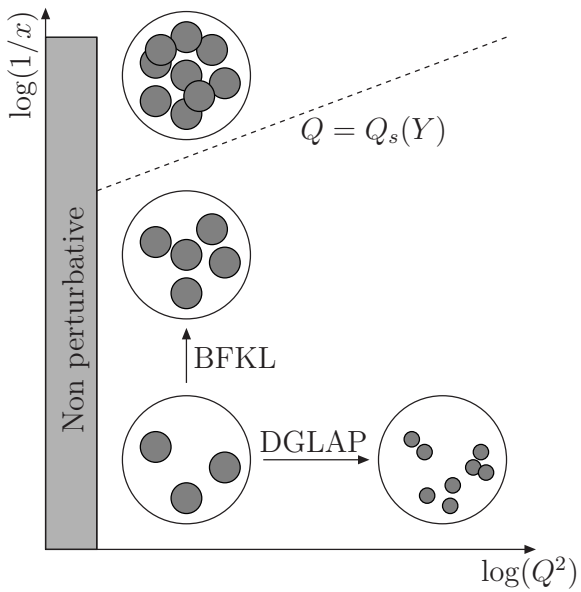
Here: dipole-dipole scattering



from Golec-Biernat, Wuesthoff (arXiv: 9807513)

partonic picture

- scattering object at large N_c is collection of color dipoles
- number of dipoles increases with energy
- cross section $\sim$ 'product' of number of dipoles in the two dipole states



from Soyez (arXiv: 0605192)

gauge/gravity duality, AdS/CFT or simply holographic QCD

setup:

- strong coupling, confining framework
- large N_c: gluon dynamics (no quarks)

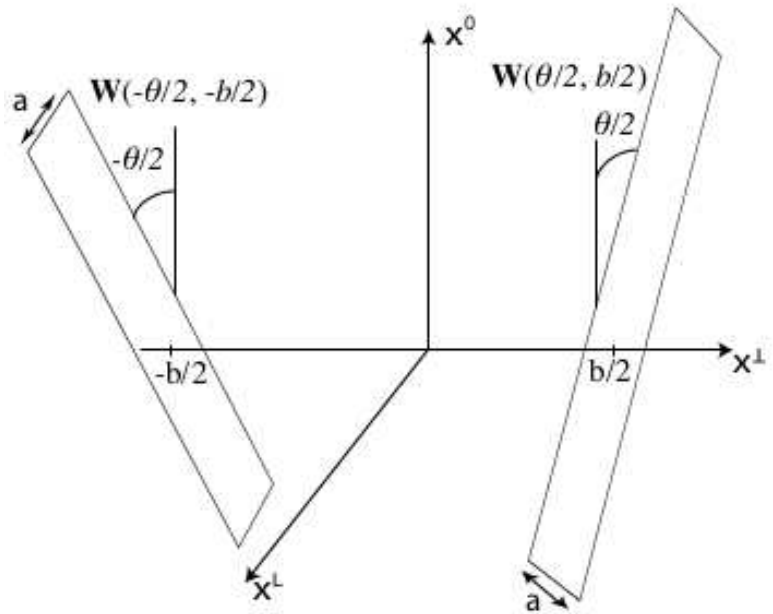
applicability:

- saturation regime (non-perturbative)
  'partonic' picture in holographic QCD?
- QCD: conformal invariance of BFKL kernel
  AdS/CFT: 'C' - conformal

dipole-dipole scattering in holographic QCD

at high energy dipole-dipole scattering amplitude described by correlator of two Wilson loops **W**

$$\frac{1}{-2is}\mathcal{T}(\theta, q_\perp) \approx \int d^2\mathbf{b}_\perp \; e^{iq_\perp \cdot \mathbf{b}_\perp} \, \mathbf{WW}$$



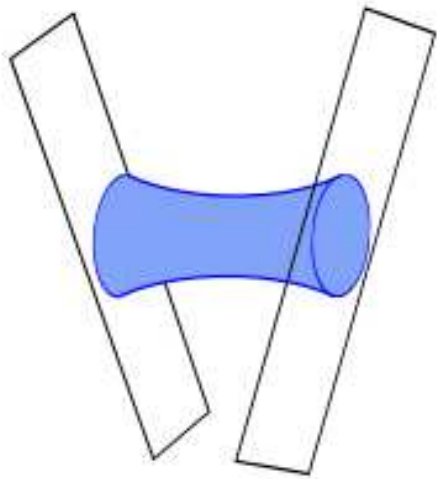
stringy Schwinger-mechanism: closed string exchange

$$\mathbf{WW} = g_s^2 \int_0^\infty \frac{dT}{2T} \mathbf{K}(T)$$

$\mathbf{K}(T)$ a string partition function ($T \sim$ circumference of string)

cylinder topology in curved AdS_3 $\perp$-space:

$ds_\perp^2 = \frac{1}{z^2}\left(dx_\perp^2 + dz^2\right)$ with hard-wall cutoff at some z_0



dominant contribution:

$$\mathbf{WW}_{poles} \approx -\frac{g_s^2}{4}\left(2\pi\alpha'\right)^{D_\perp/2} \; zz' \; \mathbf{N}(\chi = \ln\frac{s}{s_0}, \mathbf{b}_\perp, z, z')$$

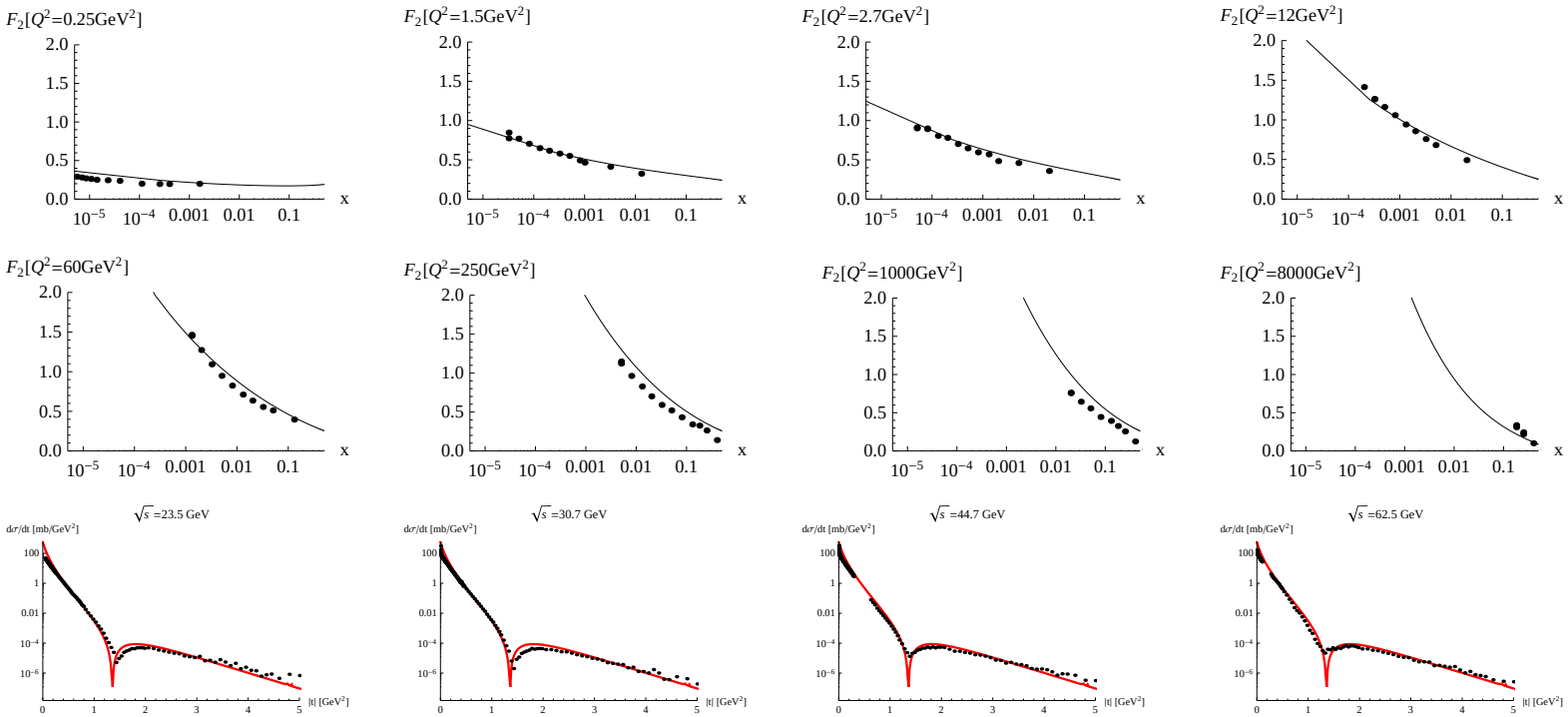
wee-dipole density $\mathbf{N}(\chi, \mathbf{b}_\perp, z, z')$

cloud of small dipoles around parent dipole (initial state)

- identify 5th dimension z with dipole size ($\sim$ inverse virtuality)
- impose 'parton' number conservation at IR cutoff

tags to QCD: BFKL pomeron exchange as large size limit

comparison to experiment: proton F_2, diffractive pp scattering, DVCS, JPsi production etc.



good fit with QCD parameters (λ, N_c, z_0)

Entropy from initial state

in gauge/gravity duality:

- entropy interpreted as area of a black hole in bulk

Here: no black hole yet **BUT** can release *wee-dipoles*

- exchanged string carries entropy!

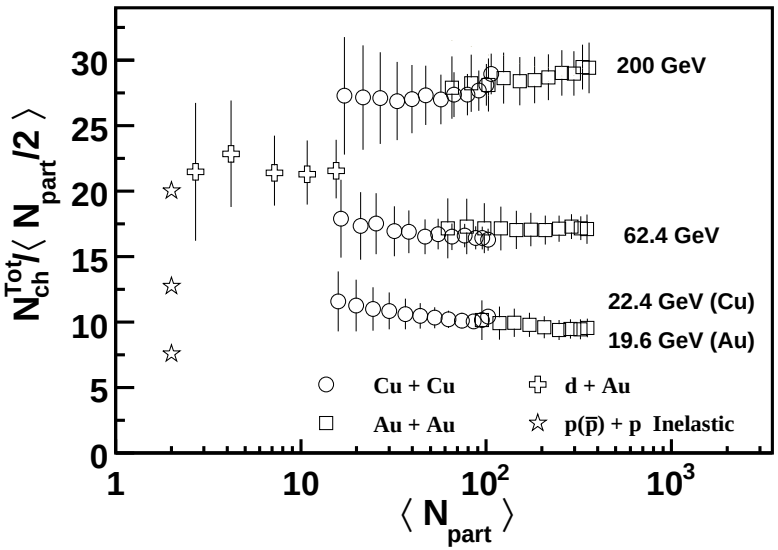
$$\Rightarrow S = \ln \mathbf{N}^2$$

(compare: thermal: $S \sim \ln \mathbf{N}$; Poissonian: $S \sim \ln \sqrt{\mathbf{N}}$)

'thermalization' time: $t_{therm.} = \frac{l_s}{4} \frac{1}{\chi^3}$

Multiplicites

from pp (dipole-dipole) to AA scattering



Interpretation/Explanation: jump from winding of the string!

$$S_{AA} \sim S_{pp} \sum_k \frac{1}{k}$$

Conclusions

- established dipole-dipole scattering amplitude in holographic QCD
- *wee-dipole* density **N** allows to enter the stongly coupled saturation region
- **N** tags to BFKL expectations and experiment (*pp* scattering, vector meson production, ...)
- interpretation of entropy production from scattering amplitude
- estimate time for entropy deposition ('thermalization' time)
- from *pp* to *AA*: 'jump' in multiplicities encoded in winding of the string